Characterization of Solid Oxide Fuel Cell Sealant Material G18 by Microindentation

Alexandra Woldman, Cornell University, 2009 SURF Fellow
Faculty Mentor: Dr. Hamid Garmestani          Graduate Mentor: Jackie Milhans

Introduction
Solid oxide fuel cells (SOFC) require a hermetic seal between the fuel and air side of the electrodes in order to function properly. The cracking or leaking of an SOFC seal is the end of the useful life of the fuel cell. An ideal sealant is chemically compatible with neighboring fuel cell components and structurally stable. The sealant must also have mechanical and thermal properties similar to neighboring components in order to prevent failure from cracking caused by mismatched coefficients of thermal expansion in connected elements of the fuel cell. Fuel cell components heat to 800°C when in use and return to room temperature when turned off. The sealant must function well at both room and elevated temperatures in addition to withstanding thermally induced stresses over time.

The sealant material G18 was developed by Pacific Northwest National Laboratory for use in fuel cells. The material is a multiphase barium-calcium-aluminosilicate glass-ceramic with approximately 55% crystallinity after initial aging. Added aging increases crystallinity and dramatically changes the properties of the material. The objective of this project is to use microindentation to characterize the bulk strain rate sensitivity and stiffness of G18 at various stages of aging at elevated testing temperatures.

Method
The strain rate sensitivity experiment was performed using displacement rates ranging from 2.4x10⁻⁴ to 10.9x10⁻⁴ in/sec. The experiment used a microindentation device with a tungsten carbide tip with a 30° apex angle to indent a G18 sample that was aged for 4 hours at 750°C. A displacement rate of approximately 4x10⁻⁴ in/sec was used for testing at elevated temperatures. The samples were heated by a 100W 120V cartridge heater until they reached a testing temperature of 100, 200 and 300°C. Room temperature (22°C) was tested as a control. The G18 samples tested at elevated temperatures were aged 0, 5, 10, 48, 75 and 100 hours at 800°C in addition to the normal aging of 4 hours at 750°C. The slope of the load-displacement curve for each sample was used to determine the stiffness for the test.

Results and Discussion
The stiffness of G18 is a positive logarithmic function of displacement rate as shown in Figure 1. The outlier is likely caused by inconsistency in the slope of the load-displacement curve for one test due to microscopic failures or slipping of the sample.

![Figure 1. Correlation between displacement rate and stiffness of G18 sample](image)

The changes in stiffness with increased aging and increased testing temperatures showed several trends as seen in Figure 2. For all samples except that aged for 100 hrs, the stiffness increased at higher testing temperatures. The largest stiffness of 15513 lbs/in was in the sample aged 75 hours. The next two largest stiffness values occurred in the samples aged 48 hours and 100 hours, indicating that increased aging leads to stiffer samples. This increased stiffness in caused by higher crystallinity from aging.

![Figure 2. The change in stiffness of G18 with increased aging and testing temperature](image)

Conclusion
The bulk strain rate sensitivity and bulk stiffness at various stages of aging and increased testing temperatures of SOFC sealant G18 was characterized by microindentation. The stiffness is logarithmically proportional to the displacement rate with a positive correlation between the two. The stiffness of the samples increased with higher testing temperatures for most samples. Stiffness also increased with aging with peak stiffness occurring at 75 hours of aging.